Goldman Sachs

Mortgage Securities

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How Should Mortgage Investors Look at Actual Volatility?

Interest rate volatility has been a recurring theme in the mortgage market, especially as rates have held to a narrow range for such a long period. The stability of this range has come to play a major role in the market's perception of mortgage risk. The traditional measures of volatility almost uniformly *overstate* the variability of interest rates over the past two years. At the same time, the traditional measures *understate* the degree of risk facing mortgage investors in the event of even a moderate rally to new lows in rates. These circumstances make it an appropriate time to review a variety of ways of looking at actual volatility — and this variety is much broader than commonly appreciated. In particular, we contrast and discuss the relevance of different:

- historical experiences,
- yield curve maturities,
- sampling windows,
- high-low range measures, and
- measurement units (e.g., percentage volatility vs. basis point volatility).

Actual and Implied Volatility

Actual (or realized, or historical) volatility is the variability of yield changes (or price changes) experienced over a specified period of data, whereas implied volatility is an estimate derived from an option pricing model. That is, actual volatility is a measure of historical volatility of yields, and implied volatility is an indicator of expected future volatility inferred from prices in the derivatives markets. Both historical and implied volatilities can be used to estimate future actual volatilities, which in turn are necessary for valuing interest rate options and swaptions, as well as embedded options such as the prepayment option implicitly sold when a mortgage is purchased.

Implied volatility (around forward yields) and actual volatility (around spot yields) are seldom equal and, in fact, are often significantly different. Both aspects of volatility can affect mortgage performance, as the dollar cost of negative convexity increases directly with both implied volatility (for option hedging strategies) and actual volatility (for duration rebalancing strategies). For a detailed discussion of both implied and actual volatility, and their effects on mortgage performance, see "Volatility and the Mortgage Market: A Primer" in the July 3, 1997, issue of *Mortgage Market Comment*. In brief, actual volatility increases the need and cost to periodically rebalance MBS durations. Actual volatility matters more than implied volatility to most total-return investors, as well as to most banks, because their use of options is often limited.

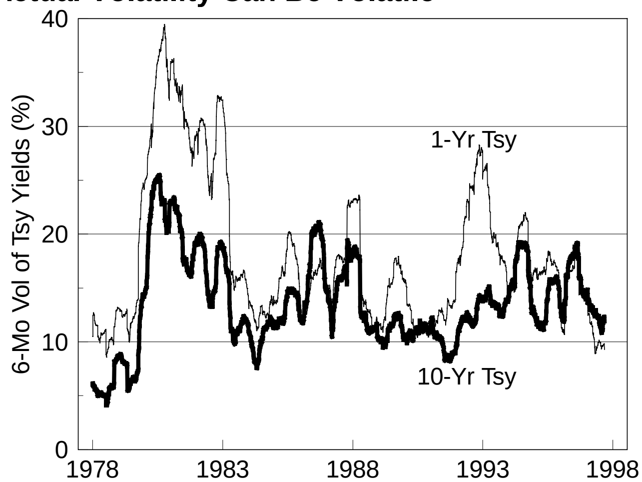
Starting this week, we will be displaying a variety of yield volatility measures in Exhibit 9 on page A-6. The exhibit contains both actual and implied volatility measures that should be of interest to mortgage investors and that illustrate several of the points we discuss in this article.

Different Historical Experiences

In the graph on the next page, we show a 20-year history of actual volatility of Treasury yields. Here we have computed actual volatility as the six-month ***standard deviation of annualized daily percentage changes in yields.*** As illustrated in the graph, actual volatility has been quite variable over time.

In the mid- to late 1970s, between the two oil shocks, interest rates were held to a fairly smooth trend and volatility was quite low. From 1980 through 1982, on the other hand, interest rates were extremely volatile as the Fed drastically altered monetary policy to wring inflation out of the economy. Since then, Treasury volatility has been somewhat more range-bound, rising and falling primarily in response to uncertainty about the business cycle and Fed policy. During 1996, for example, the days of monthly payroll releases averaged more than three times the 10-year Treasury volatility of non-payroll days.

Actual Volatility Can Be Volatile



How relevant are actual volatility levels from historical periods? If you believe that these periods represent unique or abnormal episodes that are unlikely to shed any light on the future, then historical volatility is of limited value. If, instead, you believe that the range of historical market behavior is reasonably typical of what might be experienced going forward, then historical volatility can indeed provide useful guidance. Over the past three years — and, in fact, the past *13* years — six-month actual volatility averaged 14% for 10-year Treasury yields, and one to three percentage points higher for one-year Treasury yields. While the future could certainly be different, we consider these historical volatility levels at least to be good reference points for long-term mortgage valuation.

Different Yield Curve Maturities

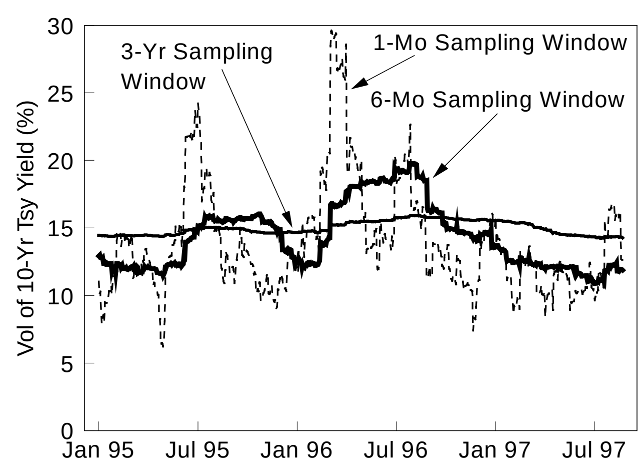
Note that volatilities on different parts of the yield curve do not generally coincide. As the previous graph illustrates, short-maturity yields are usually more volatile than long-maturity yields. Over the past six months, however, the actual percentage volatility of one-year Treasury yields has been near a 20-year low, while the volatility of 10-year Treasury yields has been significantly higher. This "inverted term structure" of actual volatility is historically quite unusual (as befits the unusual nature of current economic conditions).

Short-maturity yields are usually what trigger the caps on floating rate MBS coupons, whereas longer-maturity yields are usually what trigger the embedded prepayment option. Thus, ARMs and CMO floaters are sensitive to the volatility of short-maturity Treasuries. Likewise, fixed rate pass-throughs and CMO structures are most sensitive to the volatility of five- to 10-year Treasuries. The specific mortgage security determines which yield curve volatilities are most relevant.

Different Sampling Windows

Since actual volatility is typically calculated as the standard deviation of annualized percentage changes in yields over a specified period, the result depends strongly on the length of this historical "window," which can be any number of days, months, or years. The graph below illustrates the effect of changing the sampling window for the measurement of actual 10-year Treasury volatility. Longer windows result in smoother measures of actual volatility that are more stable over time and less prone to experience short-term blips in response to isolated one-time events. Shorter-window volatilities are less sluggish and show more drastic changes in response to recent changes in yields.

The Sampling Window Greatly Affects Actual Volatility Measurements



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As usual, the “best” historical window depends on the horizons of both the investor and the security. For short holding periods, three- or six-month volatility measures may be most suitable. For longer holding periods, or for cash flows with long-dated optionality such as mortgages, swaptions, and agency debentures, more-appropriate historical windows may be one to two years, or even longer. (Regardless of market pricing, it’s rare that five to 30 days of new information can truly justify altered volatility expectations for five to 30 *years*.) A compromise approach is to use a time-weighted methodology, which preserves a long sampling period but places more weight on more recent yield movements.

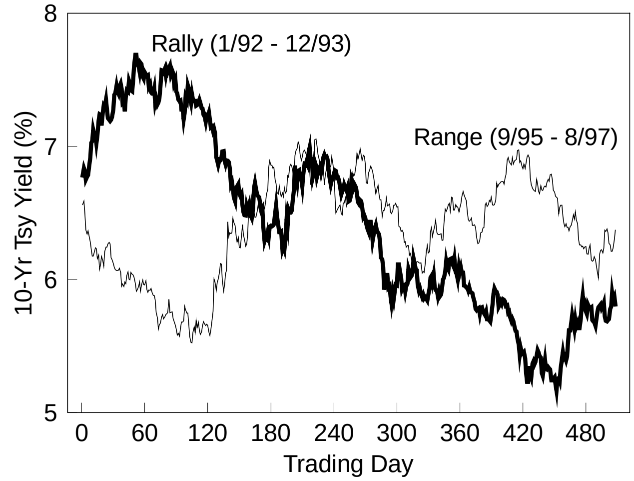
Different High-Low Range Measures

To improve actual volatility measurements, another strategy (less common, but useful when data quality is high) is to make use of the highest and lowest interest rates from a historical time period. Extreme rate levels often convey more-relevant information than day-to-day market movements — and are more likely to affect option exercise. The actual range of interest rates is particularly important for the mortgage market, where a tight one- to two-year range generally means greater certainty about prepayments, durations, supply and demand patterns, and other mortgage risk factors. Likewise, new lows in rates (or new highs, for that matter) tend to create greater uncertainty and a disproportionate amount of risk.

For a good contrast, consider the graph at right, comparing the historic two-year “rally” (1/92–12/93) with the most recent two-year “range” (9/95–8/97). Which two-year period was more volatile?

As it turns out, the answer depends entirely on how volatility is measured. By the traditional definition, actual volatility was in fact *lower* during the 1992–93 rally than during the 1995–97 range! But every mortgage investor would agree that it felt like just the reverse: The type of actual volatility that “matters” for mortgages was quite high during 1992–93 and quite low during 1995–97.

In Which Two Years Was Volatility More Severe?



	Traditional Volatility	High-Low Volatility
Rally (1/92 - 12/93)	13.5%	16.8%
Range (9/95 - 8/97)	14.4%	10.4%

One solution is an alternative volatility calculation based purely on the high and low yields of the historical period: specifically, 0.60 times the difference between their natural logarithms, times an annualization factor. (This formula was introduced by Michael Parkinson in 1976. His 0.60 multiplier brings the formula into line with the traditional volatility definition for lognormal random walks.) As an example of the calculation, the high and low 10-year CMT yields over the 9/95–8/97 period (24 months) were 7.06% and 5.53%. The high-low formula leads to a historical volatility measure of just 10.4%:

$$0.60 \times (\ln 7.06 - \ln 5.53) \times (12/24)^{0.5} = 10.4\%.$$

This is much more in line with the perception of low actual volatility for the period, as against the traditional measure of 14.4%. Similarly, the high-low volatility measure of 16.8% for the 1992–93 period reflects the convexity cost of that rally much better than the traditional measure of 13.5% actual volatility. (This has in fact been the more typical pattern: A preponderance of “trend” years has caused high-low volatility to average somewhat higher than traditional volatility.) Mortgage investors should certainly consider incorporating range-based measures into their volatility framework.

Different Measurement Units

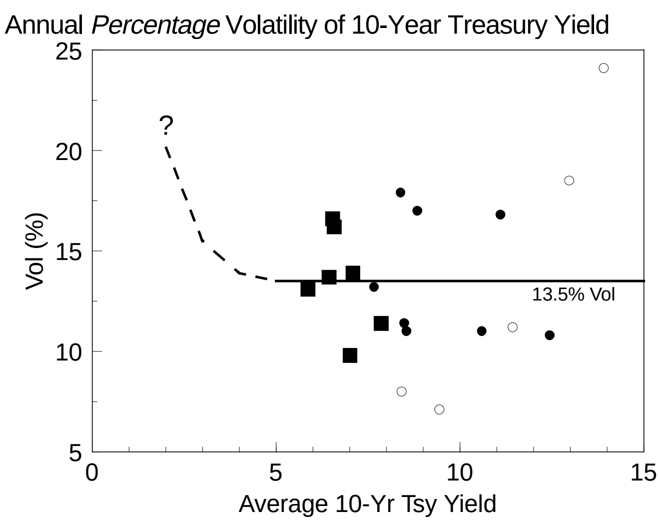
Thus far, we have referred to actual volatility in percentage terms — so-called percentage volatility. Another way to compute actual volatility is in basis point terms, which is approximately the market interest rate multiplied by percentage volatility.

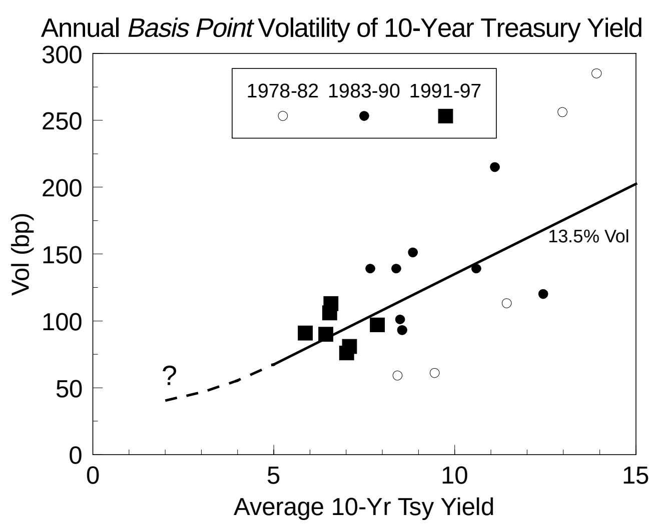
The choice of basis point or percentage volatility depends on which measure is likely to be more consistent at different future interest rate levels. Percentage volatility is appropriate if the magnitudes of daily interest rate movements tend to be proportional to the level of rates (e.g., 4 bp at a 4% yield level, 8 bp at an 8% yield level). Basis point volatility is appropriate if the magnitudes of daily rate movements are completely independent of the level of rates (e.g., 6 bp regardless of yield level). Though the two models of interest rate behavior both have some appeal (and are often hard to distinguish over short data periods), the truth is probably somewhere in between.

In recent years, some percentage implied volatility measures have exhibited directionality, or a fair amount of negative correlation with market interest rates. Several theories have been proposed to explain this directionality. First, the directionality of long-dated volatility may be the result of investors, dealers, and servicers increasing purchases of implied volatility (options) to hedge mortgage positions when interest rates fall; or it may be the result of their raising actual volatility by making large, frequent adjustments to their Treasury hedges. Second, directionality may result from increased volatility as interest rates reach "new lows" and uncertainty increases regarding MBS prepayment rates and hedges. Third, directionality may exist because the Federal Reserve has tended to move in discrete rate steps. If monetary policy is always implemented in 25 bp increments, then an easing or tightening at a 5% yield level induces proportionally more volatility than an identical policy move at a 9% yield. Fourth, directionality may reflect shortcomings in the option-pricing models used to calculate implied volatilities.

None of these theories are very satisfactory for explaining the directionality of long-dated implied volatilities. For although these percentage implied volatilities have been strongly correlated with interest rates over the last few years, percentage *actual* volatilities have not displayed this behavior at all. In the graphs on this page, we plot one-year

Actual Percentage Volatility Hasn't Been Significantly Correlated With Yield Levels Over Any Recent Time Period. At Lower Yield Levels, Actual Percentage Volatility May Increase as Basis Point Volatility Levels Off.





actual volatility in both basis point and percentage terms, using annual data for the last 20 years. The left-hand chart shows little relationship between actual percentage volatility and the level of interest rates. Conversely, the right-hand chart shows a roughly proportional relationship between actual basis point volatility and the market rate level. This finding is in stark contrast with the directionality observed in implied swaption volatilities over the past couple of years. This divergence poses a serious issue for the calibration of dynamic yield curve models and option pricing models.

It is quite possible that, at lower rate levels than have been experienced over the last 20 years, basis point volatility would level off, and percentage volatility would indeed start to increase. Recent data in Japan (and very old data in the U.S.) have shown that basis point volatility does *not* decline to zero in proportion with rate levels, and percentage volatility *does* rise as a result. But the record in both the U.S. and Japan shows that the inflection point does not occur until rates sink beyond 4% or so.

Future Directions

The most sophisticated measures (and forecasts) of actual volatility tend to combine several of the desirable features we've been discussing, including long-term windows and ranges, short-term movements and time-weighting, plus statistical adjustments for complications such as directionality and mean reversion. (Moving average Garman-Klass and GARCH calculations are probably the best-known examples of higher-level volatility measures.) Though more complex, these types of volatility measures are potentially the most realistic for valuation purposes, as they attempt to blend the many dimensions of actual interest rate volatility that most market participants are concerned with. We will be returning to this active area of research in future articles of this series.

Conclusion

The question of the "right" way to incorporate volatility into MBS analysis is by no means a simple one. Both actual and implied volatility can affect mortgage performance, and both of them can be measured in a wide variety of ways. We encourage mortgage investors to consider a broad set of volatility indicators in shaping their investment strategies, and our new weekly Exhibit 9 is being introduced in this spirit.